AB03

Current-induced Domain Wall Motionand Wall Transformations

M. Kläui*

Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany

*Corresponding author: Mathias.Klaeui@Uni-Konstanz.de, Phone: +49 7531 883786, Fax: +49 7531 883789

While current-induced domain wall motion is experimentally well established [1-3], the underlying theory of interaction between current and magnetization is still controversial [4-5].

We have used primarilyx-ray magnetic circular dichroism photoemission electron microscopy (XMCDPEEM) to image in addition to the displacement of domain walls, the wall transformations by the nucleation and annihilation of vortices due to the spin torque effect [3]. In Fig. 1, XMCDPEEM images of the domain wall spin structures are shown together with corresponding micromagnetic simulations including the spin transfer torque terms. Starting from a transverse wall, a transformation to a vortex wall (clockwise magnetization circulation with the vortex core pointing out of the plane) occurs after a single pulse injection. After another pulse injection the wall transforms back to a transverse wall, but this time with transverse magnetization pointing opposite to the original transverse wall. After another pulse injection the wall is again a vortex wall (clockwise magnetization circulation with the vortex core pointing into the plane). This observation is qualitatively in line with the theoretically predicted periodical nucleation and annihilation of vortices by Thiaville et al. [5]. The observed spin structures give already a good indication of the transformation mechanism involved but further direct evidence was obtained when a wall was caught in the process of being transformed (Fig. 1 (5)). Here the vortex core is pushed off centre as predicted theoretically [5] and the good agreement with the micromagnetic simulation corroborates the transformation mechanism suggested by the theory.

We have further investigated the temperature dependence of the spin torque effect by measuring field- and current-induced wall propagation at different temperatures. Surprisingly jcrit increases with increasing temperature, which means that the spin torque effect is less efficient at high temperatures [6]. This finding might help to explain discrepancies between the experimental results obtained at 300K and the theoretical 0K calculations. Furthermore our measurements at different temperatures allow us to obtain the propagation field as a function of the injected current density, which can be fitted to obtain the size of the non-adiabatic contribution [5,6].

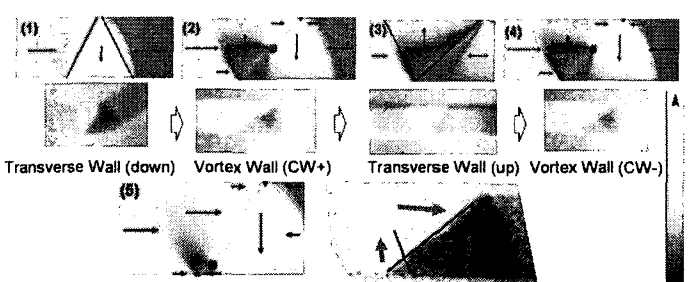

Fig. 1. (1-4) XMCDPEEM images and micromagnetic simulations of DW spin structures (W=1.5μm, t=10 nm Py) after consecutive pulse injections (10^{12} A/m^2). A periodic transformation is observed (1-2-3-4-1...) and the transformation from (4) to (1) takes place by vortex core displacement as see in (5).

REFERENCES

[1] M. Kläui et al., Appl. Phys. Lett. **83**, 105 (2003); Phys. Rev. Lett. **94**, 106601 (2005) Phys. Rev. Lett. **95**, 26601 (2005).
[2] M. Kläui et al., Appl. Phys. Lett **88**, 232507 (2006).
[3] J. Grollier et al, APL **83**, 509 (2003) N. Vernier et al., EPL **65**, 526 (2004) A. Yamaguchi et al., PRL **92**, 77205 (2004).
[4] G. Tatara et al., Phys. Rev. Lett. **92**, 86601 (2004) W. J. Kim et al., doi:10.1016/j.jmmm.2006.10.943 (2007).
[5] A. Thiaville et al., Europhys. Lett. **69**, 990 (2005) J. He et al., PRB **73**, 184408 (2006), JAP **98**, 16108 (2005).
[6] M. Laufenberg et al. Phys. Rev. Lett. **97**, 46602 (2006) P. Dagras et al., J. Phys. D **40**, 1247 (2007).

AB04

Nucleation and Dynamics of Magnetic Vorticies in Nanowire by Spin-polarized Current

Y. Nakatani*[1], J. Shibata[2], G. Tatara[3,4], H. Kohno[5], A. Thiaville[6], and J. Miltat[6]

[1]Department of Computer Science, University of Electro-communications, Chofu, Tokyo, 182-8585, Japan
[2]RIKEN-FRS, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan
[3]Department of Physics, Tokyo Metropolitan University, Hachioji, Tokyo, 192-0397, Japan
[4]PRESTO, JST, 4-1-8 Honcho Kawaguchi, Saitama, Japan
[5]Graduate School of Engineering Science, Osaka University, Toyonaka, Osaka 560-8531, Japan
[6]CNRS-Universite Paris-sud, Laboratoire de physique des solides, Bat. 510, 91405 Orsay cedex, France

*Corresponding author:nakatani@cs.uec.ac.jp, Phone: +81 42 443 5306, Fax: +81 42 443 5306

Spin manipulation in magnetic nanostructure by spin polarized current is a hot topic, and many works of magnetization reversal in pillar system, domain wall motion in nano wire and vortex motion in a single nanodot are reported [1-8]. Another important aspect of the spin polarized current is that it leads to an instability of the uniformly magnetized state [9]. This instability was shown to trigger domain wall formation in a narrow wire by analytic method [9]. In this paper, we demonstrate by micromagnetic simulation that the instability of the uniformly magnetized state in wide wires leads to formation of vortices. A detailed description of vortex pair creation, pair dynamics and pair annihilation under spin current is obtained by micromagnetic simulation. Domain walls are shown to be created via individual annihilations of vortices through the sample edges.

REFERENCES

[1] J. C. Slonczewski, J. Magn. Magn. Mater., 159, L1-L7 (1996).
[2] L. Berger, Phys. Rev. B, 54, 9353-9358 (1996).
[3] A. Yamaguchi, T. Ono, S. Nasu., K. Miyake, K. Mibu & T. Shinjo, Phys. Rev. Lett., 92, 077205 (2004).
[4] G. Tatara, & H. Kohno, Phys. Rev. Lett., 92, 089901 (2004).
[5] S. Zhang S. & Z. Li, Phys. Rev. Lett., 93, 127204 (2004).
[6] A.Thiaville, Y. Nakatani, J. Miltat. & Y. Suzuki, Europhys. Lett., 69(6), 990-996 (2005).
[7] T. Ishida, T. Kimura, & Y. Otani, Phys. Rev. B, 74, 014424 (2006).
[8] J. Shibata, Y. Nakatani, G. Tatara, H. Kohno, & Y. Otani, Phys. Rev. B, 73, 020403(R) (2006).
[9] J. Shibata, G. Tatara, & H. Kohno, Phys. Rev. Lett., 94, 076601 (2005).